Transient Structure Current Generated by the Activation of a Squib Device

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SUMMARY AND CONC'L.US1ONS

Experimental measurements of the currents in pyre-activation circuit show that a structure current is generated during the pyre-activation process. This current is a transient current and is an intense source of electromagnetic interference. Analysis has indicated that the noise voltage induced on candidate victims circuits is sufficient to cause circuit upset and/or latchup.

A survey of flight anomaly records has also correlated the occurrence of anomalies with the pyre-activation process. Detailed analyses, taking the spacecraft cabling configuration and circuit sensitivities into account, have shown that the structure current induced noise voltage could definitely be the cause of the anomalies.

The threat of the structure current due to pyre-activation can be alleviated by isolating the pyre-activation circuit from ground and by proper arrangement of the cables in sensitive circuits.

1. INTRODUCTION

The deployment of mechanical systems in space flight is often accomplished with pyrotechnic devices. The activation element of a pyrotechnic device is a squib, such as the NASA Standard Initiator (NSI). In a capacitor discharge activation circuit, a high current (> 5 Amp) is applied to the bridge wire inside the device. The bridge wire then heats up the explosive materials within the device and is eventually disrupted by the force of the explosion. The entire process is a fast transient event (< 10 μs) and electromagnetic interference (EMI) are generated by the turn on/off of the current to the bridge wire, To avoid coupling of pyre-generated EMI to sensitive circuits, the wires in the squib initiating circuit are usually shielded and twisted. However, even with standard EMI design fully implemented in the pyre- activation circuits, anomalies that could be attributed to the pyro generated EMI were still experienced on space flights. An example is the Magellan computer anomaly (corruption of 4 Kbytes of memory) which occurred during the separation of the solid rocket motor casting by the activation of six NSI devices (3 separation nuts). Further research in this area has indicated that the cause of anomaly is in the transient structure current induced by the pyre-firing process. The loss of Mars Observer uplink also coincided with the pyre-firing process (Ref. 1), and the structure current induced EMI mechanism was also regarded as one of the possible candidate mechanism for the uplink loss. In order to understand the cause of the Magellan and Mars Observer flight anomalies, tests were performed to duplicate the events leading to the anomalies. A relatively large database was obtained. Some of the test results will be discussed in this paper.

2. SQUIB AND SQUIB ACTIVATION CIRCUIT

A squib device is an electro-explosive device (EED). It is activated by a energy storage circuit which provides the necessary current to activate the device. A simplified squib activation circuit is shown in Figure 1. The battery in Figure 1 is the energy source, the voltage output of the battery is in 20-40 Volt range. A large current (20 to 40 Amp) will flow in this circuit once the